Trace elements in leaves of trees and shrubs in south Spain: ecosystem perspectives

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Global Change affects directly to plant physiology, growth and fitness, causing changes on communities assembly, and lastly on the dynamics of nutrients and carbon cycles in the ecosystem. In particular, modifications in the proportion of different leaf traits have consequences for ecosystem functioning, through the processes of primary production and litter decomposition. Thus the decomposition rates are determined by the chemical composition of litter (which are strongly determined by the chemical composition of the green leaf), and by the moisture and temperature conditions in the soil. The objectives of this study are 1) to describe the leaf spectrum of variability in the accumulation of trace elements for Mediterranean woody species, 2) to evaluate the use of leaves as bioindicators of soil quality, 3) to analyse the contribution of differential trace element accumulation among woody species to the ecosystem heterogeneity.

We compare results from two forest areas in south Spain: a mixed oak forest in Aljibe Mountains and a remediated and afforested floodplain in the Guadiamar valley. In the mountain forest we explore the variability in the accumulation of trace elements in the leaves of 17 woody species. We analyse the bi-directional relationship with soil heterogeneity (Quilchano et al. 2008). Plants uptake elements from the soil volume explored by the roots (besides the aerial deposition on leaves), and at the same time affects the ecosystem through the species-specific leaf traits, including decomposition rates and concentration of trace elements.

In the floodplain afforested area we use leaf concentration of trace elements as biomonitor of soil quality after remediation of a mine-spill , and to assess the risk-based effects of contaminants on ecosystems (Madejón et al. 2006). In general the bioaccumulation coefficients (plant/soil concentration quotients) were low (<0.4) for all the trace elements and the eight studied plant species, with the exception of Cd and Zn in *Populus alba* which accumulated up to 3 mg kg-1 of Cd and 410 mg kg-1 of Zn (Domínguez et al. 2008).

The combined multivariate analysis of the concentration of eight trace elements in leaves of 25 woody species allows to infer the relative importance of the species factor and the site factor in trace element patterns. The influence of the biogeochemistry of trace elements on the ecosystem behaviour is discussed.

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Leaf Trace Element Spectrum in Woody plants in South Spain

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Introduction

Green leaf chemical composition is fundamental for biogeochemical cycles in terrestrial ecosystems. Leaves contain not only essential but also non-essential elements that are uptaked and transported into leaves mainly by non-specific mechanisms. Little is known about the role of trace elements in leaf decomposability and ecosystem functioning in Mediterranean woodlands. As a prospective study, **we explored the variability in trace element concentrations (TE) over a range of Mediterranean woody plant species.** We calculated the transfer of these elements from soils to leaves and assessed the importance of the site and the plant species in the variability of TE contents in leaves.

Fig. 1. Location of sampling sites within the Iberian Peninsule.

Table 1. Studied species

1 *Arbutus unedo*	12 *Myrtus communis*	23 *Quercus ilex*
2 *Celtis australis*	13 *Nerium oleander*	24 *Quercus suber*
3 *Crataegus monogyna*	14 *Osyris alba*	25 *Rosmarinus officinalis*
4 *Cistus salvifolius*	15 *Olea europaea*	26 *Rosa serpervirens*
5 *Ceratonia siliqua*	16 *Populus alba*	27 *Retama sphaerocarpa*
6 *Callicotome villosa*	17 *Phillyrea angustifolia*	28 *Rubus ulmifolius*
7 *Erica arborea*	18 *Phyllirea latifolia*	29 *Smilax aspera*
8 *Erica scoparia*	19 *Pistacia lentiscus*	30 *Salix atrocinerea*
9 *Fraxinus angustifolia*	20 *Pinus pinea*	31 *Tamarix africana*
10 *Lonicera implexa*	21 *Phlomis purpurea*	32 *Teucrium fruticans*
11 *Lavandula stoechas*	22 *Quercus canariensis*	33 *Teline linifolia*

Methods

Our data set includes **469 leaf samples of 33 woody plant species** (**Table 1**), collected between 2003 and 2008 at two sites at S Spain (**Fig.1**): Aljibe Mountains (unpolluted mixed oak forests) and Guadiamar Basin (polluted woodlands). TE were analyzed by wet extraction with HNO_3 and determination by ICP-MS. Corresponding soils (0-25 cm) were also analyzed to calculate soil-plant transfer coefficients (concentration$_{leaf}$: concentration$_{soil}$). Site and plant species were introduced as random factors in a **variance components analysis** by the Residual Maximum Likelihood Method (REML).

Results

The TE concentrations were highly variable across the samples, as reflected by coefficients of variations > 100 for all elements, except Ni (**Fig. 2**).

Leaf composition reflected the origin of the samples (**Fig. 3**), with a high intercorrelation of non-essentials such as As, Cd and Tl. Thus, the factor "site" accounted for a high percentage of the variance of most elements (**Fig. 4**). Only for Ni, the factor "species" explained a higher percentage than factor "site" (around 25 %).

Soil-leaf transfer was highly different across elements and species. The lowest inter-specific differences were found for Ni and Zn (**Fig. 5**). In most of cases, species are "excluders" of TE, with transfer coefficients < 0.3. However, some "accumulator species" (transfer coefficients > 1) were detected, such as *C. salvifolius*, *O. alba* and *S. atrocinerea* for Cd, and *Q. ilex* for Mn.

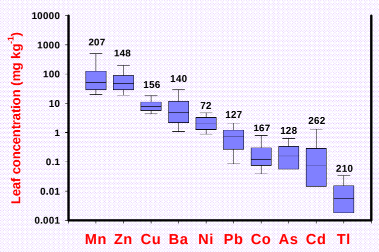

Fig. 2. Box-Plots of the variability in TE concentrations in the 469 leaf samples. For each element, coefficients of variation are indicated.

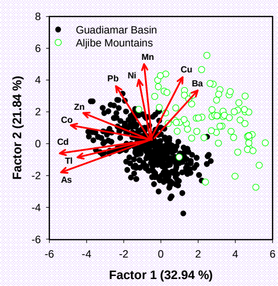

Fig. 3. Principal Components Analysis of leaf composition, distinguishing between sampling sites.

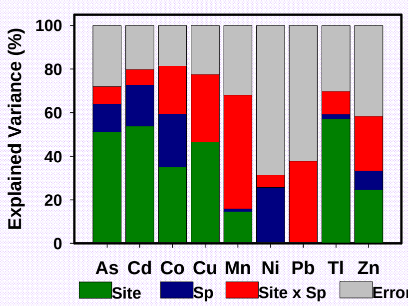

Fig. 4. Factors explaining the variability in TE concentrations in the studied species.

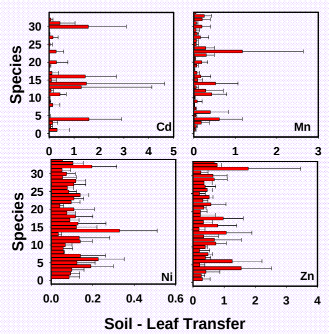

Fig. 5. Examples of Soil-Leaf transfer coefficients of several TE, for each of the studied species.

Conclusions

Mediterranean woody species differs in their patters of accumulation of TE. Although growing site is highly determinant for leaf composition, there are high inter-specific differences for some elements. The role of these elements in litter dynamics and ecosystem functioning deserves more attention.

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